STUDIES ON DIFFUSIVITY OF NAPHTHALENE BALLS USING A FLUIDIZED BED

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By

Gurudev Pradhan

Roll No- 111CH0082

Under the guidance of

Prof. (Mrs). Abanti Sahoo

Department of Chemical Engineering
National Institute of Technology
Rourkela, 769008

National Institute of Technology Rourkela

CERTIFICATE

This is to certify that this report entitled, "**STUDIES ON DIFFUSIVITY OF NAPHTHALENE BALLS USING FLUIDIZED BED**" submitted by **Gurudev Pradhan** in partial fulfilments for the requirements for the award of Bachelor of Technology Degree in Chemical Engineering at **National Institute of Technology, Rourkela** is an authentic work carried out by him under my guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Place: Rourkela

Date:

(Thesis Supervisor)

Prof. (Mrs) Abanti Sahoo

Associate Professor

Dept. of Chemical Engineering

National Institute of Technology, Rourkela

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Place: Rourkela

Date:

Gurudev Pradhan

111CH0082

Dept. of Chemical Engineering

National Institute of Technology, Rourkela

ABSTRACT

Molecular diffusion is principal to mass transport and comprehension the fundamental component of this wonder and quantitative estimation of the same is discriminating to mass exchange operations. It is critical to highlight the way that any modern mass exchange operation includes multi-segment framework; nonetheless, suitable binary system data can be effectively used to estimate the multi-component system. In this project, a study has been conducted to measure the diffusivity of naphthalene in a fluidized bed. The experiments had been conducted on naphthalene balls in a fluidized bed with a conical bed. Parameters like time of diffusion, temperature of air, flow velocity of air and material to be diffused were varied and the diffusion coefficients were determined. Naphthalene balls ($C_{10}H_8$) were used to study the diffusion phenomenon in spherical geometry. The diffusivity was determined using the Fick's model. This model suitably depict the diffusion coefficients of naphthalene balls considering the diverse exploratory conditions. A relationship was created between the diffusion coefficients and the framework parameters. The values acquired from the relationship were contrasted with the test values which gave deviation inside exploratory limits of confinement. Finally the effect of each parameter on the diffusion coefficient was determined.

Key words: Diffusion coefficients, Fluidized bed, Mass transfer operation, Naphthalene, velocity

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NOMENCLATURE

t	: diffusion time, in mins
T	: temperature of air, in ^{o}C
V	: flow velocity of air, in m/sec
Iw	: initial weight, in gm
Fw	: final weight, in gm
Lw	: loss in weight, in gm
d_p	: initial diameter, in cm
$d_{p'}$	: final diameter, in cm
D_{AB}(lit)	: diffusivity literature, in m^2/sec
D_{AB}(cal)	: diffusivity calculated, in m^2/sec
%dev	: percentage deviation
ρ_A	: density, in kg/m^3

ABBREVIATIONS:

VC	:	Vernier coincident
MSD	:	Main scale division
lit	:	Literature
cal	:	calculated
LC	:	Least count
P_{AS}	:	Vapor pressure of naphthalene

CHAPTER 1

INTRODUCTION

1.1 Background of the Research

Mass transfer can either be diffusional or convective. In the event that, there is no outer mechanical unsettling influence then mass exchange happens because of diffusion system. Nonetheless, when there is a plainly visible unsettling influence in the medium, which then again extraordinarily impacts the rate of mass transfer, it turns into a convective transport. Accordingly, the stronger the stream field, making additionally mixing and turbulence in the medium, the higher is rate of mass exchange. The idea of molecular diffusion is essential and is broadly utilized as a part of assortment of investigative and designing applications. Whenever there is transport of any gas/liquid/solid molecules occur through a stagnant zone characterized by a laminar flow regime, the importance of molecular diffusion is more evident. Indeed, when there is a turbulent movement sets into the procedure, there dependably remains a laminar zone near to the stage limit generally impacting the stream instrument [1]. Diffusion is the procedure which transports material starting with one piece of a framework then onto the next as a consequence of irregular molecular movements without mixing. Standard diffusion happens in isothermal, isobaric frameworks with no outside power-field gradient. It exchanges mass starting with one locale then onto the next in light of fixation inclinations when the mixture is stationary or in laminar stream toward the concentration gradient [2].

The diffusion rate is portrayed by Fick's first law of diffusion which expresses that the mass flux of a component per unit area is corresponding to the concentration gradient. The proportionality calculate Fick's law, known as the diffusion coefficient, is a property of the species included framework, and is very nearly composition autonomous, increments with temperature and changes conversely with pressure for low density gasses [1].

Transport in a permeable medium is an established sample where molecular diffusion occurs. A normal sample is the diffusion of reactants and products in a permeable impetus pellet. Other than ordinary pore dispersion, Knudsen and surface diffusion as well plays an important role in determining the performance of a catalyst. To be exact, study of molecular diffusion is the central premise to the investigation of mass transfer when all is said in done. Mass exchange is the premise of numerous compound and organic techniques.

The organic frameworks incorporate oxygenation of circulatory system and the vehicle of particles crosswise over layer within the kidney and so on. It is critical to highlight the way that any mechanical mass exchange operation includes multicomponent framework; notwithstanding, suitable parallel framework information can be viably used to gauge the multi-part framework. Essentially, for any unit operation including more than a solitary stage (and subsequently vicinity of an interphase), it is the neighborhood or general mass exchange coefficient which clarifies the mass exchange operation winning inside the framework and can be viably measured in wetted wall section tests. Nonetheless, suitably measured diffusivity information can without much of a stretch be utilized as a part of evaluating the mass exchange coefficients utilizing crucial ideas of different prescient hypotheses like (film, penetration, surface reestablishment and boundary layer).

Naphthalene is a covalent solid to utilize for the determination of mass-transfer coefficients in numerous liquid stream circumstances. It has a moderately high melting point indicate in connection its vapor pressure, probably a result of its auxiliary symmetry, and at room temperature it gives a sensible compromise between the need to achieve quantifiable rates of mass exchange and the undesirability of an excessively fast change fit as a fiddle or size [3].

Fluidization is the operation by which fine solids are changed into a liquid like state through contact with a gas or solid. The procedure of fluidization with hot air is very appealing for the dissemination of distinctive materials. An instigated draft is made by method for blower and outside air is sucked into the unit. This hot air stream grows the material at certain speed and making turbulence in the item. Fluidized beds are broadly utilized as a part of various gas-strong applications where noteworthy heat and/or mass exchange rates are required.

Advantage of using Fluidized bed:

- In fluidized beds, the contact of the solid particles with the fluidizing medium is greatly enhanced when compared to packed beds. This conduct in fluidized combustion beds empowers great thermal transport inside the framework.
- Good heat transfer between the bed and its compartment which can have a noteworthy heat limit whilst maintaining a homogeneous temperature field.
- High heat and mass exchange rates, in view of good contact between the particles and the drying gas.
- Uniform temperature and bulk moisture content of particles, because of concentrated particle blending in the bed.
- Good temperature control and operation up to the most astounding temperature.
- High drying limit because of high proportion of mass of air to mass of product.

1.2 Objective

In this task work, accentuation has been focused upon to calculate the binary diffusion coefficient of Naphthalene balls with varying geometries. Parameters like time of diffusion, temperature of air, flow velocity of air and material to be diffused are to be considered. The experiments are planned to be carried out by varying one of the parameter keeping rest of the parameters constant using Fluidized Bed.

To study the effects of different parameters like temperature, time and velocity, initial variable weights on diffusion coefficient of Naphthalene balls with varying geometries.

1.3 Chapter Layout

Chapter 2 is highlighted on the literature review which includes the basic concepts of Diffusion.

Chapter 3 is highlighted on the experimental set-ups such as Fluidized bed.

Chapter 4 is about the materials and method used for the calculation of Diffusion Coefficient of Naphthalene balls.

Chapter 5 is about the observations, the effects of each parameter on Diffusion coefficient of naphthalene is studied and its results and also highlighted on the discussion.

Chapter 6 is highlighted on the conclusion and future work.

Chapter 2

Literature Review

2.1 Principles of diffusion

Diffusion is the development of individual segments affected by a physical jolt through a mixture. The most widely recognized reason for diffusion is a concentration gradient of the diffusing part. A concentration gradient has a tendency to move the part to the segment in such a bearing as to level focuses and pulverize the gradient. At the point when the gradient is kept up by always supplying the diffusing segment to the high fixation end of the gradient and uprooting it at the low-concentration end, there is an enduring state flux of the diffusing part. This is the normal for some mass exchange operations.

The molecules of the scent when interacts with air and forms a concentration gradient and the segments of aroma is tend to move from higher fixation to the lower fixation and thusly the particles of the fragrance is being spread and the odor of the aroma can go further and further[7].

2.2 Theory of diffusion

Molecular diffusion is the thermal movement of fluid or gas particles at temperature above outright zero. The rate of this movement is an element of temperature thickness of the liquid and the mass or size of the molecule. Diffusion clarifies the net flux of a particle from a district of higher concentration to one of lower concentration. Molecular diffusion can be characterized as the exchange of individual atoms through a liquid by method for the irregular individual movement of particles. Molecular diffusion is ordinarily depicted scientifically utilizing Fick's laws of diffusion.

2.2.1 Fick's law of diffusion

Fick's law is only meant for binary diffusion and steady state flow. Fick's laws of diffusion describe diffusion and can be used to solve for the diffusion coefficient, *D*. They were derived by Adolf Fick in the year 1855[7].

2.2.1.1 Fick's first law of diffusion

Fick's first law relates the diffusive flux to the concentration field, by hypothesizing that the flux goes from districts of high concentration to areas of low concentration, with an extent that is relative to the concentration gradient. Here just molecules are moving entire greater part of particles is not in movement.

Hence for this system Fick's law can be defined as

$$J_{AZ} = -CD_{AB}\left(\frac{dx_A}{dz}\right) \qquad (2.1)$$

Where (dX_A/dz) is the concentration gradient per unit length and

D_{AB} is the diffusion constant.

J_{AZ} diffusional flux of unit (mole/m2.sec)

C is the total concentration of A and B in (moles/m3)

X_A is the mole fraction of A in concentration of A and B.

The negative sign indicates that the diffusion occurs in the direction where there is drop in concentration.

2.2.1.2 Fick's second law of diffusion

Fick's second law predicts how diffusion causes the concentration to change with time. At the point when steady state diffusion happens in one course in a strong or stagnant liquid, the administering differential mathematical statement is called Fick's second law of diffusion.

$$\frac{dC_A}{dt} = D_{AB}\left(\frac{d^2C_A}{dx^2}\right) \qquad (2.2)$$

2.3 Steady State Diffusion

In this area, enduring state molecular mass exchange through straightforward frameworks in which the concentration and molar flux are elements of a solitary space direction will be considered. In a parallel framework, containing A and B, this molar flux toward z, is given by:

$$N_A = -CD_{AB}\frac{dY_A}{dz} + Y_A(N_A+N_B) \tag{2.3}$$

2.4 Diffusion in spherical Geometry

If there should arise an occurrence of dispersion in round geometry let us consider an volatile solid that has radius 'r_s' at any instant 't'. Imagine a thin spherical shell of inner radius 'r and thickness Δr around the solid. This is a binary system involving diffusion of molecule 'A' through air 'B'. Then,

Rate of input of A into the thin shell (at r = r) : $(4\pi r^2)N_{A|r}$

Rate of output of A from the thin shell (at r = r+ Δr) : $(4\pi r^2)N_{A|}r + \Delta r$

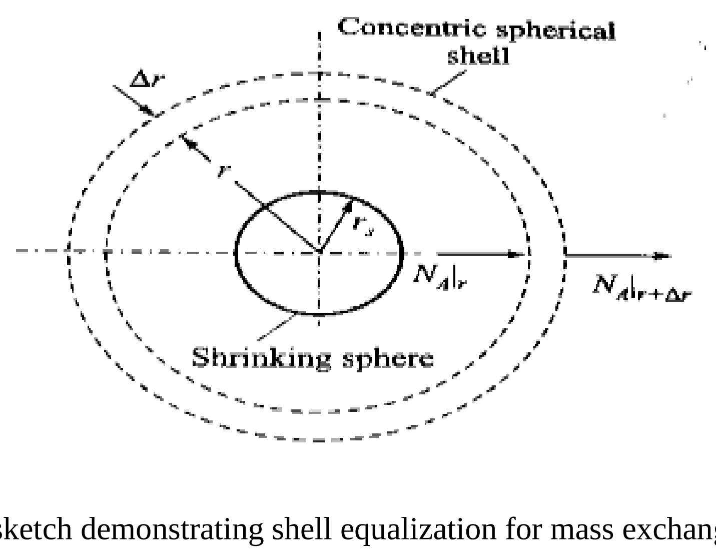

Figure 1: A sketch demonstrating shell equalization for mass exchange from a circle.

The rate of accumulation = 0

By a steady state mass balance,

Input - output = accumulation

$$(4\pi r^2)N_{A|r} - (4\pi r^2)N_{A|}r + \Delta r = 0$$

Dividing both sides by Δr and taking the limit Δr→0,

$$\lim_{\Delta r \to 0} \frac{(4\pi r^2)N_{A|r} - (4\pi r^2)N_{A|r+\Delta r}}{\Delta r}$$

$$\Rightarrow -\frac{d}{dr}(4\pi r^2 N_A) = 0$$

$$\Rightarrow 4\pi r^2 N_A = \text{constant} = W \qquad (2.4)$$

Equation 2.6 is a very important result for steady state diffusion through a variable area and can be generalized as

(Area)(Flux) = Constant

So, the case corresponds to diffusion of A through non diffusing B. Since diffusion occurs in radial direction, we get

$$N_A = (N_A + N_B)\frac{P_A}{P} - \frac{D_{AB}}{RT}\frac{dP_A}{dr} \qquad (2.5)$$

Putting NB = 0 and rearranging,

$$N_A = -\frac{D_{AB}P}{RT(P-P_A)}\frac{dP_A}{dr}$$

From equation 2.4 and 2.5, we get

$$-\frac{dP_A}{P-P_A} = \frac{WRT}{4\pi D_{AB}P}\frac{dP_A}{dr^2} \qquad (2.6)$$

Equation 2.6 can be integrated from r = r_s to r = ∞ where $P_A = P_{A\infty}$. Here P_{AS} is the vapor pressure of the molecule and $P_{A\infty}$ is the partial pressure of the molecule in the bulk air. By integrating the rate of sublimation W is

$$W = \frac{4\pi D_{AB} P r_s}{RT} \ln \frac{P - P_{A\infty}}{P - P_{AS}} \tag{2.7}$$

Rate of sublimation,

$$W = -\frac{d}{dt}\left(\frac{4}{3}\pi r_s^3 \frac{\rho_A}{M_A}\right) = -4\pi\frac{\rho_A}{M_A} r_s^2 \frac{dr_s}{dt} \tag{2.8}$$

The negative sign is induced because the size of the solid decreases with time.

Equating equations (2.7) and (2.8)

$$-4\pi\frac{\rho_A}{M_A} r_s^2 \frac{dr_s}{dt} = \frac{4\pi D_{AB} P r_s}{RT} \ln \frac{P - P_{A\infty}}{P - P_{AS}} \tag{2.9}$$

We have made utilization of the “pseudo-enduring state” suspicion, that the particle size changes so gradually that the diffusion of the substance through the encompassing air happens essentially at steady state[4].

If at time t = 0, the diameter of the molecule is d_p and at time t it is $d_{p'}$. Then,

$$D_{AB(lit)} = \frac{(d_p^2 - d_{p'}^2) RT\rho_A}{8PtM_A} \ln \left(\frac{P - P_{AS}}{P}\right) \tag{2.10}$$

2.5 Formula used for calculation:

2.5.1 Size and Shape:

The measurement of naphthalene balls were measured by Vernier caliper. The least count of Vernier caliper was dead set. Naphthalene ball was set between the lower jaws of Vernier caliper and primary scale division and Vernier correspondent was recorded.

$$d_p = M.S.D + (V.C * L.C) \qquad (2.5)$$

2.5.2 Diffusivity Calculation:

The diffusion coefficient of naphthalene balls was computed from Fick's model.

The correlation formula used is

$$D_{AB(lit)} = \frac{(d_p^2 - d_{p'}^2)RT\rho_A}{8PtM_A} \ln \left(\frac{P-P_{AS}}{P}\right) \qquad (2.5.1)$$

2.5.3 Analysis of Diffusivity:

Endeavor has been made to study the diffusivity of naphthalene balls through a fluidized bed in the present study. Fick's diffusion mathematical statement has been utilized for the count of compelling diffusivity of tests.

$$D_{AB(cal)} = 2E\text{-}15\,[(T^{7.1589})*(t^{0.2512})*(V^{1.1303})*(Iw^{-3.029})]^{0.9185} \qquad (2.5.3)$$

Where t is time, T is temperature; V is the velocity of air and Iw is the initial weight.

2.5.4 % of Deviation:

It helps us to know the amount of error we experienced while performing the trial. On the off chance that the %deviation is inside 20%, then our watched qualities are thought to be remedy.

$$\left[\frac{D_{AB(cal)} - D_{AB(lit)}}{D_{AB(lit)}} \right] * 100 \qquad (2.5.4)$$

2.6 Data used for Naphthalene balls:-

Formula = $C_{10}H_8$

Diameter of naphthalene balls (d_p) = 1.86 cm

Molar mass (M) = 128.174 gm/mole.

Atmospheric pressure (P) = 101.321 KPa

Value of gas constant (R) = 8.3145 Pa m^3 K^{-1} mol^{-1}

Table 1: Data for density of naphthalene at different temperatures [5].

Sl.no	T(°C)	ρ_A (kg/m^3)
1	60	1070.88
2	70	1024.8
3	80	978.72
4	90	972.140

Table 2: Data for vapor pressure of naphthalene at different temperatures [6].

Sl.no	T(°C)	P_{AS} (KPa)
1	60	0.2448
2	70	0.5012
3	80	0.933
4	90	1.5544

Chapter 3

EXPERIMENTAL SETUP

3.1 Schematic representation of fluidized bed.

The fluidized bed is used to provide the necessary hot air required for rapid diffusion. The setup is a tapered fluidized bed drier consisting of Air Compressor, Air Distributor, Heater, Inlet Air Temperature Sensor, Tapered Bed, Outlet Air Temperature Sensor.

3.1.1 Apparatus in the set -up:

1. Air Compressor; 2. Heater; 3. Air inlet to the bed; 4. Inlet air temperature sensor; 5. Tapered Fluidized Bed; 6. Outlet Hot Air Temperature Sensor; 7. Hot Air outlet; 8. Timer

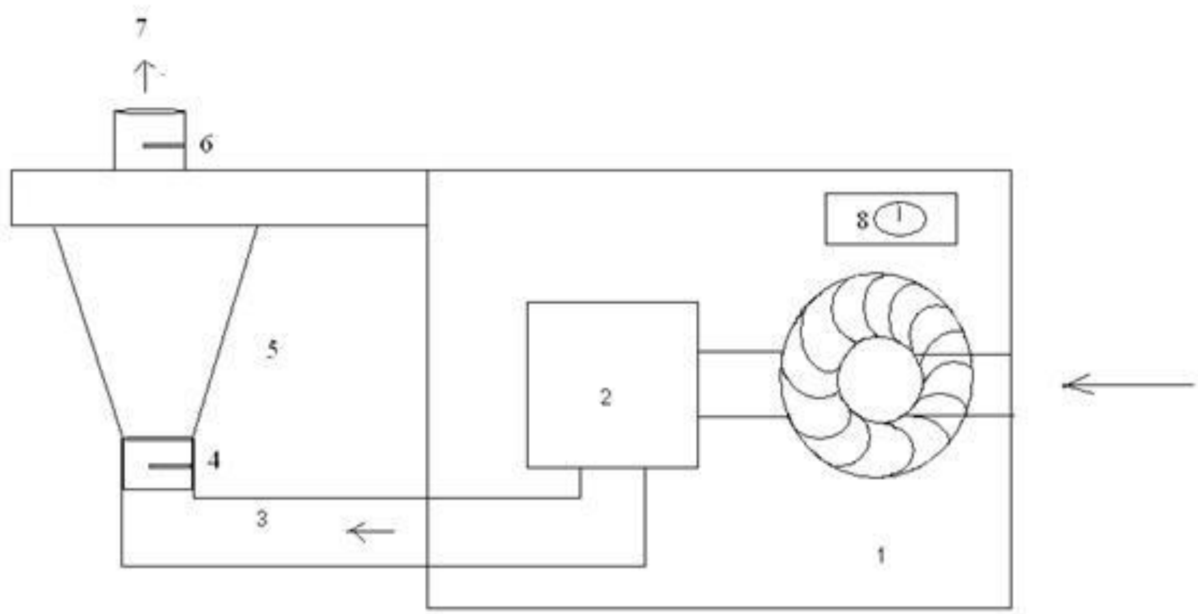

Figure 2: Tapered Fluidized Bed.

3.2 Tapered Fluidized Bed Dryer

The bed is formed like a truncated cone with base breadth is 12.1 cm where as the top distance across is 21.96 cm. The reactor stature is 20 cm. The decreased point is 14°. The gas merchant was 2 mm thick with 2 mm apertures. A fine wire lattice of 0.2 mm openings was spot welded over the wholesaler plate to capture the stream of solids from the fluidized bed into the air chamber. Air from the blower was warmed and nourished into the air chamber and into the fluidization section. The electrical radiator comprised of various warming components of 2 KW rating. The clock is given in which time can be kept up from 0- 80 min

3.3 Temperature controller

A temperature controller, gave to the air chamber, encouraged the control of air temperature to ± 0.5° C, for the working scope of 40-110°.

3.4 Air movement

The choice and estimating of a fan to move air through a dryer is vital. The major imperviousness to the stream of air originates from the grain bed. The weight drop through the bed support is of lesser impact, especially for profound beds. The weight drop over a grain bed is an element of the air speed and the grain itself.

Chapter 4

MATERIALS AND METHOD

4.1 Materials

Naphthalene balls having same spherical geometry are taken as a sample.

4.2 Method

i. A fluidized-bed was used for the drying of all samples.
ii. The fluidized bed was joined with a heat pump dehumidifier framework. A temperature of 100°C were situated by the temperature controller in the heat pump dehumidifier framework, and the set-up was run for 10 minutes to accomplish relentless steady state before material presentation.
iii. For each of the observations, varying one of the parameters keeping rest of the parameters constant the corresponding particle diameter was calculated by Vernier caliper and diffusivity was computed by the above mentioned formulae.
iv. For observation of temperature effect of a naphthalene balls, the temperature was set in 4 different temperatures where time, velocity and initial weights were constant and same procedure was repeated.
v. For observation of time effect, time was set in 4 different times where temperature, velocity and initial weights were constant and same procedure was repeated.
vi. For observation of velocity effect, velocity was set in 4 different times where temperature, time, initial weights were kept constant and same procedure was repeated.
vii. For observation of initial variable weights effects, variable weights was set in 4 different times where temperature, time, velocity were kept constant and same procedure was repeated.
viii. The observed information were ascertained, arranged and plotted beneath.

Chapter 5

RESULTS AND DISCUSSION

The experiments are planned to be carried out by varying one of the parameter keeping rest of the parameters constant using Fluidized Bed.

5.1 Observations

5.1.1 Observation 1 (variation of temperature):

Initially 200gm of naphthalene balls were taken in the fluidized bed. The varying temperature of 60 °C, 70 °C, 80 °C and 90 °C were situated by the temperature controller in the heat pump dehumidifier framework. The hot air velocity passing through the naphthalene balls was kept at a constant value of 3.8 ms-1, and the weight loss was determined after 25mins of time duration. The final particle diameter was then calculated with the help of a Vernier caliper. The value of diffusivity was then computed by using above mentioned formula. This process was repeated for 3 other different temperatures.

Table 3: Dimensions of sample 1 with varrying temperatures.

Sl.no	t (min)	T (°C)	Iw (gm)	Fw (gm)	Lw (gm)	V (m/sec)	d_p' (cm)	D_{AB}(lit) (m^2/sec)
1	25	60	200	150	50	3.8	1.74	2.69E-09
2	25	70	200	123	77	3.8	1.55	8.24E-09
3	25	80	200	91	109	3.8	1.4	2.11E-08
4	25	90	200	63	137	3.8	1.33	4.92E-08

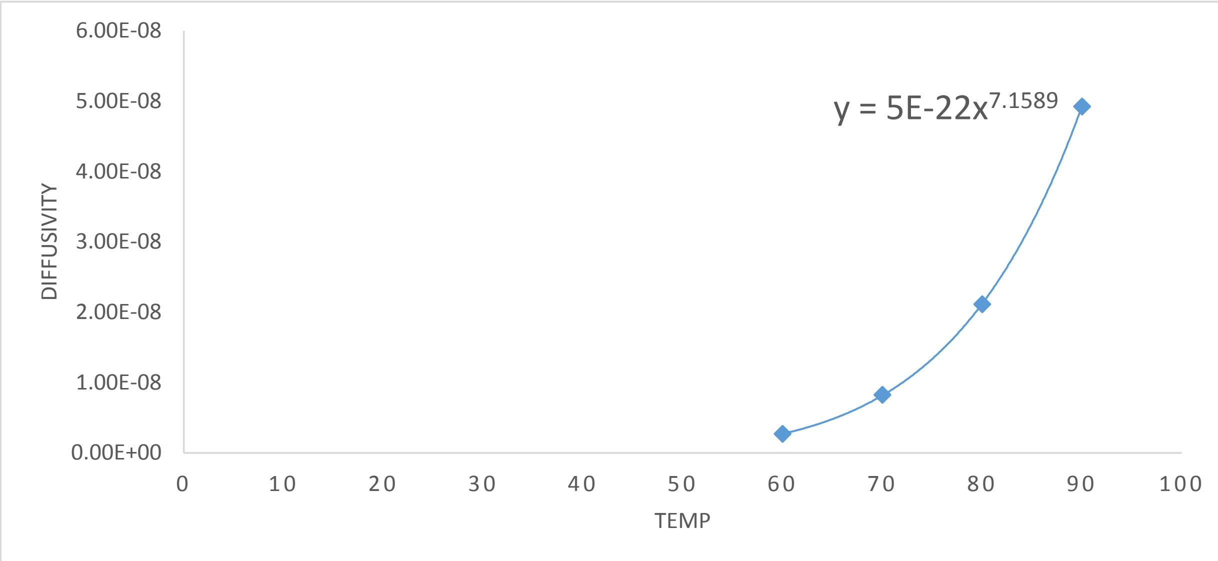

Figure 3: Variation of diffusivity against temperature.

5.1.2 Observation 2 (variation of time):

Initially 200gm of naphthalene balls were taken in the fluidized bed. A constant temperature of 70 °C were situated by the temperature controller in the heat pump dehumidifier framework. The hot air velocity passing through the Naphthalene balls was kept at a constant value of 3.8 ms^{-1}, and the weight loss was determined after every 5mins of interval. The final particle diameter was then calculated with the help of a Vernier caliper. The value of diffusivity was then computed by using above mentioned formula.

Table 4: Dimensions of sample 2 with varying time.

Sl.no	**t (min)**	**T (ºC)**	**Iw (gm)**	**Fw (gm)**	**Lw (gm)**	**V (m/sec)**	**d_p' (cm)**	**D_{AB}(lit) (m^2/sec)**
1	10	70	200	165	35	3.8	1.8	6.41E-09
2	15	70	165	151	14	3.8	1.76	6.96E-09
3	20	70	151	140	11	3.8	1.71	7.55E-09
4	25	70	140	133	7	3.8	1.65	8.07E-09

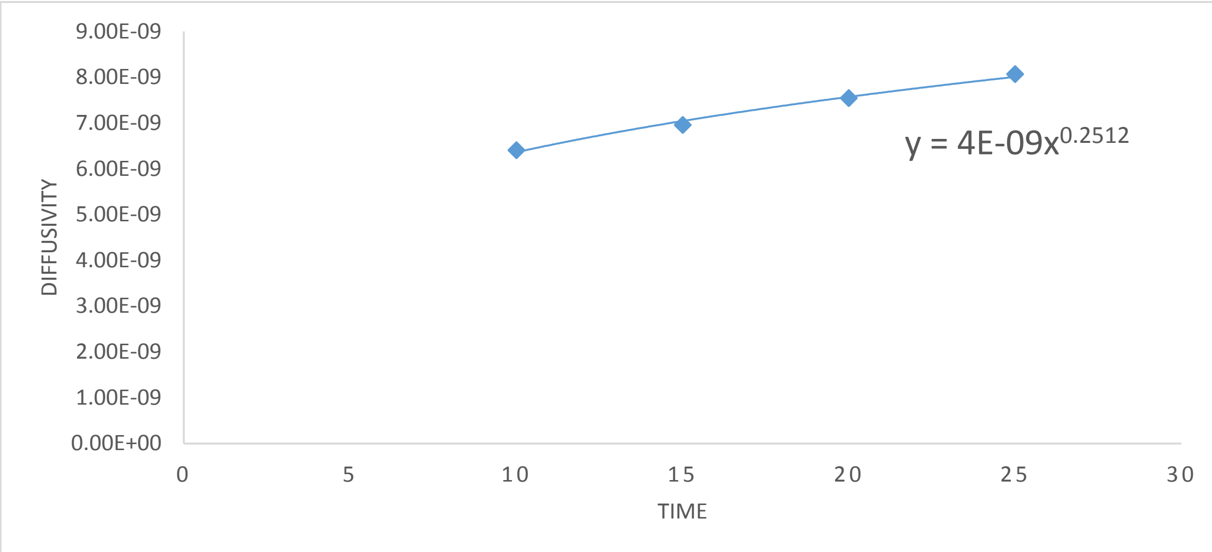

Figure 4: Variation of diffusivity against time.

5.1.3 Observation 3 (variation of velocity of air):

Initially 200gm of naphthalene balls were taken in the fluidized bed. A constant temperature of 70 °C were situated by the temperature controller in the heat pump dehumidifier framework. The hot air velocity passing through the Naphthalene balls was kept at a varying value of 3.8 ms^{-1}, 2.875 ms^{-1}, 1.95 ms^{-1} and 0.975 ms^{-1}, and the weight loss was determined after every 25mins of interval. The final particle diameter was then calculated with the help of a Vernier caliper. The value of diffusivity was then computed by using above mentioned formula. This process was continued for 3 other velocities.

Table 5: Dimensions of sample 3 with varying velocity.

Sl.no	t (min)	T (°C)	Iw (gm)	Fw (gm)	Lw (gm)	V (m/sec)	d_p' (cm)	D_{AB}(lit) (m^2/sec)
1	25	70	200	140	60	0.975	1.78	2.31E-09
2	25	70	200	126	74	1.95	1.73	4.34E-09
3	25	70	200	116	84	2.875	1.65	6.29E-09
4	25	70	200	110	90	3.8	1.5	1.12E-08

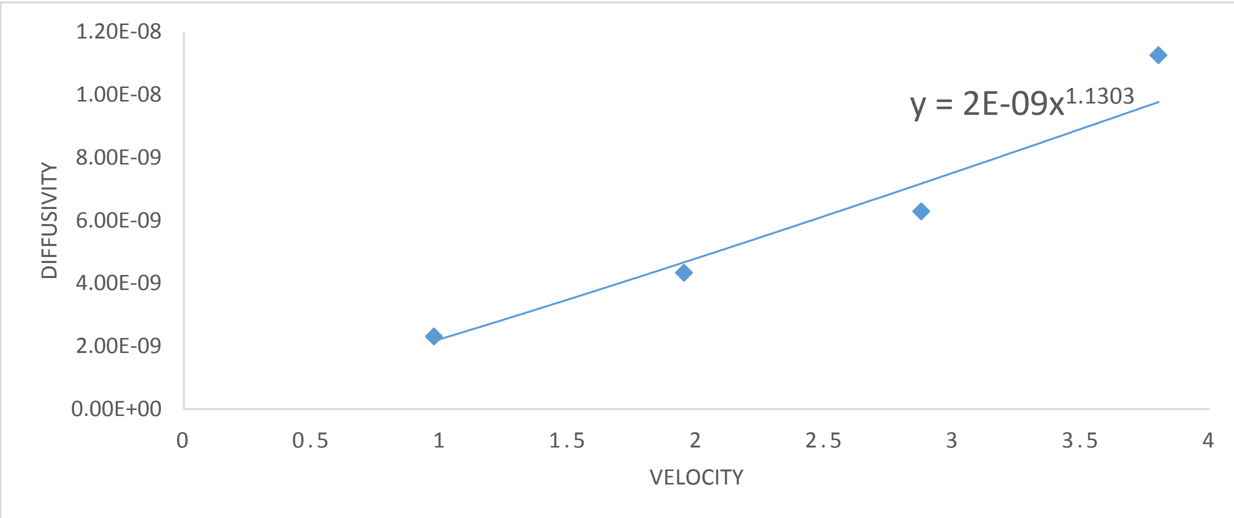

Figure 5: Variation of diffusivity against velocity of air.

5.1.4 Observation 4 (variation of initial weights):

Initially 200gm of naphthalene balls were taken in a fluidized bed. A constant temperature of 70 °C were situated by the temperature controller in the heat pump dehumidifier framework. The hot air velocity passing through the Naphthalene balls was kept at a constant value of 3.8 ms^{-1}, and the weight loss was determined after every 25mins of interval. The final particle diameter was then calculated with the help of a Vernier caliper. The value of diffusivity was then computed by using above mentioned formula. This process was continued for 3 other variable weights.

Table 6: Dimensions of sample 4 with varying initial weights.

Sl.no	t (min)	T (°C)	Iw (gm)	Fw (gm)	Lw (gm)	V (m/sec)	d_p' (cm)	D_{AB}(lit) (m^2/sec)
1	25	70	200	110	90	3.8	1.51	1.10E-08
2	25	70	250	172	78	3.8	1.64	4.15E-09
3	25	70	300	231	69	3.8	1.73	2.86E-09
4	25	70	350	288	62	3.8	1.79	1.99E-08

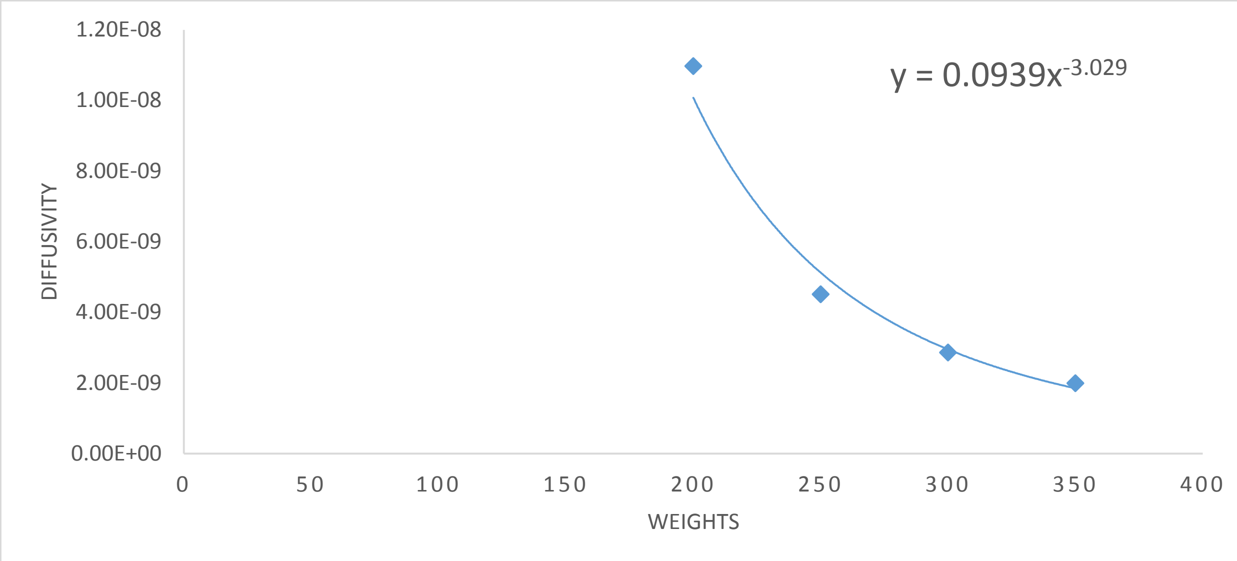

Figure 6: Variation of diffusivity against initial weights.

5.1.5 Development of correlation:

Graphs between Diffusivity and each of the parameters were plotted above. The plot should be in the form of Power curve i.e the equation representing the curve should be in the form of **$Y= mX^n$**. The power (n) tells us about the effect of that parameter on Diffusivity of Naphthalene ball. Greater the value of n, greater the effect of that parameter on the diffusion coefficient and vice versa.

The value of diffusion coefficient of the above 4 observations is calculated by using equation (2.8) gives us the value of diffusivity literature **($D_{AB(lit)}$).** The value of diffusion coefficient can also be computed without using the theoretical formula. For this, the value of Product i.e the product of 4 parameters with the value of n as their power of each parameter was calculated [2].

$$\text{Product of parameters} = (\text{temp}^{7.1589})*(\text{time}^{0.2512})*(\text{velocity}^{1.1303})*(\text{weights}^{-3.029}) \quad (5.1)$$

A Power curve was plotted between the values of Product and diffusivity literature. The equation of this plot was also in the form of $A = K(B)^C$. Then the value of Diffusivity $\mathbf{(D_{AB(cal)})}$ was computed from

$$D_{AB(cal)} = K(Product)^C \tag{5.2}$$

Then, % deviation was calculated by

$$\left[\frac{D_{AB(cal)} - D_{AB(lit)}}{D_{AB(lit)}} \right]*100 \tag{5.3}$$

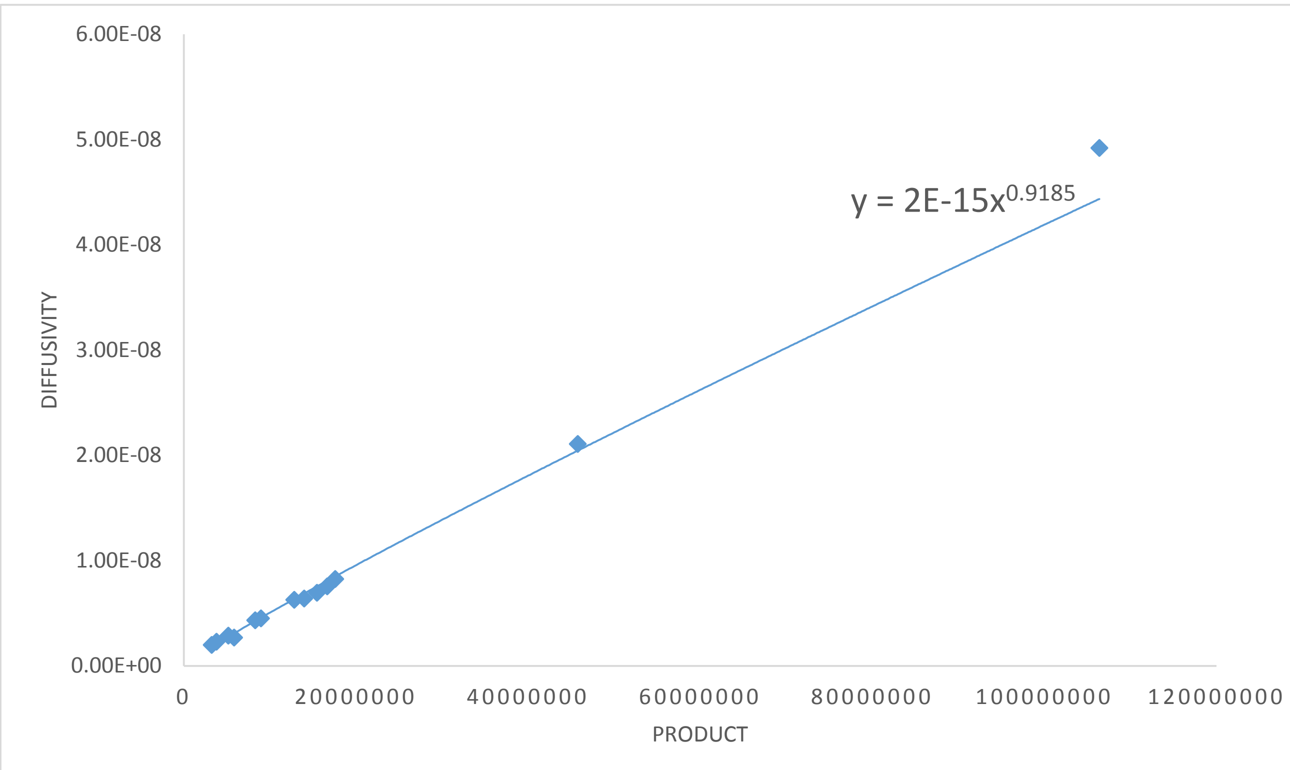

Figure 7: Variation of diffusivity against system parameters.

Table 7: Calculation of %deviation from diffusivity calculated and diffusivity literature.

Sl.no	t (min)	T (°C)	V (m/sec)	Iw (gm)	product	D_{AB}(lit) (m^2/sec)	D_{AB}(cal) (m^2/sec)	%dev
1	60	25	3.8	200	5838201	2.69E-09	3.28E-09	22.01
2	70	25	3.8	200	17601287	8.24E-09	9.03E-09	9.68
3	80	25	3.8	200	45782866	2.11E-08	2.17E-08	3.06
4	90	25	3.8	200	1.06E+08	4.92E-08	4.72E-08	-4.13
5	70	10	3.8	200	13982406	6.41E-09	7.32E-09	14.12
6	70	15	3.8	200	15481607	6.96E-09	8.03E-09	15.41
7	70	20	3.8	200	16641813	7.55E-09	8.58E-09	13.70
8	70	25	2.875	200	12841430	6.29E-09	6.77E-09	7.56
9	70	25	1.95	200	8280206	4.34E-09	4.52E-09	4.17
10	70	25	0.975	200	3782570	2.31E-09	2.20E-09	-4.70 1
11	70	25	3.8	250	8953730	4.51E-09	4.86E-09	7.71
12	70	25	3.8	300	5154233	2.86E-09	2.93E-09	2.28
13	70	25	3.8	350	3231336	1.99E-09	1.91E-09	-4.270

5.2 Results:

The following results obtained:

1. With an increase in temperature, the diffusion coefficient of naphthalene balls increases rapidly keeping other parameters constant.
2. With an increase in time of sublime, the diffusion coefficient of naphthalene balls increases keeping other parameters constant.
3. With an increase in flow velocity of air, the diffusivity of naphthalene balls increases keeping other parameters are constant.
4. With increase in initial variable weights, the diffusion coefficient of naphthalene balls decreases keeping the rest of the parameters constant.

5.3 Discussion:

There have been sure deviations in the figured worth from the experimental values as a result of the inadequacies like:

1. The speed controller in the fluidized bed is not sufficiently precise.
2. The temperatures of the solid tumbles down when we uprooted it to take the weight perusing.
3. The atmospheric moisture changes from normal, in this way the mass exchange rate of dampness does not stay steady on all days regardless of the fact that our parameters were kept consistent.
4. All naphthalene balls may not be of same size.
5. We may experience some mistake while measuring the molecule measurement of naphthalene ball.
6. Finally, human mistakes may have come up when taking the readings.

Chapter 6

CONCLUSION

6.1 The following are the findings of the present studies:

1. Fick's relationship for computation of Diffusion Coefficient were discovered to be appropriate over an extensive variety of parameters with errors within experimental limits.
2. Out of the 4 parameters, temperature has the greatest effect on Diffusivity and the rest of the 3 parameters have negligible effect. A slight change in temperature will produce a large effect on diffusion coefficient.
3. Now one does not have to use the literature formula to calculate Diffusion coefficient, in fact the use of the correlation between Diffusivity and system parameters is much more relevant.
4. Parameters like flow velocity of air, time of sublime and initial variable weights have negligible effects as compared to temperature.
5. A correlation was found between the Diffusion coefficient and the system parameters which gives results comparable to experimental values and can be applied to pilot studies and even industries.

6.2 This work can further be extended in the following areas:

1. Studies can be further extended to heterogeneous gas solid-catalytic reactions to understand the phenomena further.
2. It can be useful in processed food packaging industries for the computation of Diffusion of aroma, nutrients etc.

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